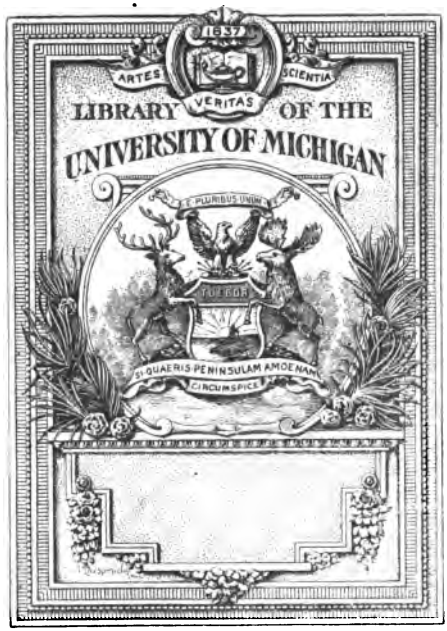
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UNIVERSITY OF CALIFORNIA.

FORMAL RECOGNITION

OF THE

TRANSFER OF THE LICK OBSERVATORY

TO THE

BOARD OF REGENTS OF THE UNIVERSITY.

I. Letter from Captain R. S. Floyd, President of the Lick Trustees, to the Regents of the University.

II. Address by and in behalf of the James Lick Trust, by Edwin B. Mastick, Esq.

III. Responsive Address in behalf of the Board of Regents, by Professor Joseph Le Conte, M.D., LL.D.

Berkeley, Wednesday, June 27, 1888.

SACRAMENTO:
STATE OFFICE, : : : : J. D. YOUNG, SUPT. STATE PRINTING.
1888.

LETTER FROM CAPT. R. S. FLOYD.

To the Regents of the University of California:

GENTLEMEN: The third Trust in the Deed of Trust of Mr. James Lick, reads as follows:

"*Third.*—To expend the sum of seven hundred thousand dollars ($700,000) for the purpose of purchasing land, and constructing and putting up on such land, as shall be designated by the party of the first part, a powerful telescope, superior to and more powerful than any telescope ever yet made, with all the machinery appertaining thereto, and appropriately connected therewith, or that is necessary and convenient to the most powerful telescope now in use, or suited to one more powerful than any yet constructed; and also, a suitable Observatory connected therewith. The parties of the second part hereto, and their successors shall, as soon as said telescope and Observatory are constructed, convey the land whereupon the same may be situated, and the telescope, Observatory, and all the machinery and apparatus connected therewith, to the corporation known as the "Regents of the University of California;" and, if after the construction of said telescope and Observatory, there shall remain of said seven hundred thousand dollars in gold coin, any surplus, then said parties of the second part shall turn over such surplus to said corporation, to be invested by it in bonds of the United States, or of the City and County of San Francisco, or other good and safe interest-bearing bonds, and the income thereof shall be devoted to the maintenance of said telescope, and the Observatory connected therewith, and shall be made useful in promoting science; and the said telescope and Observatory are to be known as 'The Lick Astronomical Department of the University of California.'"

Richard S. Floyd, Charles M. Plum, George Schonewald, and Edwin B. Mastick, surviving Trustees of the James Lick Trust, have the honor, gentlemen, through me, their President, to report that—

First.—We, together with our co-Trustee, William Sherman, deceased, have, by purchase and through gift by Congress, pro-

cured the necessary land at the site selected by Mr. James Lick himself, for his Observatory. This site is the summit of Mount Hamilton, in Santa Clara County, California, and the land secured amounts to 1,571.49 acres.

Second.—That after cutting off more than 75,000 tons of solid rock, to level the western summit of this land, "designated by the party of the first part," we have now successfully "constructed and put up" thereon a powerful telescope, which is "superior to" and is "more powerful than any telescope ever yet made." That we have provided it with all the "machinery appertaining thereto and appropriately connected therewith," and that "is necessary and convenient" to this great telescope, "more powerful than any yet constructed," and that we have also completed the construction of a suitable Observatory connected therewith.

Third.—And that in further pursuance of this third Trust, the Lick Trustees are now practically ready, and offer to deliver and convey to you this land, telescope, and Observatory, and ninety thousand dollars in United States gold coin, and afterwards whatever balance the settlement of all accounts will show to be remaining of the seven hundred thousand ($700,000) dollars, set apart by Mr. Lick for this object.

Volume 1, Lick Observatory Publications, gives detailed descriptions of all the subsidiary instruments of the Observatory. The instruments obtained since are immediately appertinent to the great telescope, such as the Star Spectroscope, Filar, and Duplex Micrometers, photographic apparatus, etc., and are listed in an inventory to be submitted to you, with the deeds of conveyance. Detailed and scientific description of these and of the great telescope will properly be left to your Director for the next volume of Lick Observatory Publications. The subsidiary equipment is considered excellent, but, of course, all such instruments have been made before, and gave little trouble beyond ordering the most modern patterns from the best makers.

What really makes the Lick Observatory is the great tele-

scope, with its machinery, and its peculiar but splendid situation. To attempt a telescope, greater than any ever yet made in the world, involved new and experimental work; and in adapting its outfit and protection to the peculiar circumstances of an exposed mountain peak, new difficulties and problems constantly confronted us.

The most momentous question of all that have arisen in this work, respected the style of telescope that should be attempted, in order to achieve the most powerful instrument possible—whether a great refracting telescope, or a great reflecting telescope.

The most eminent astronomers of the world were divided, or undecided upon this question. With the light of the best opinions, pro and con, a practical consideration of the atmospheric conditions of our exposed site, determined the Trustees to decide in favor of a great refractor. It is doubtful if a very large reflector could have its power practically realized at a site like Mount Hamilton.

I do not propose to enumerate the many and varied difficulties encountered in accomplishing this Observatory. There have been delays and disappointments, but these are unavoidable in a work of the kind. Time, in such a work, is as insignificant a consideration as would be the danger that the heavens might fly away before we got ready to look. Considering all things, the Trustees feel a grateful surprise, that this Observatory, with the most powerful telescope in existence, is an accomplished fact at all. Not until the great objective had safely arrived at the Observatory on December 27, 1886, could the Trustees feel any assurance that such would be the case. Then came the anxieties with the risks of transportation, of the mounting and the photographic lens, until December and January last. Any accident to these might have consumed the entire fund, without completing the Observatory as it now is. We feel reason to congratulate ourselves that more than our most sanguine expectations have been realized.

It was the special desire of Mr. Lick that this work should

not be carried out according to any one man's particular notions, nor built according to any single groove. The Trustees have earnestly endeavored to carry out this broad idea of the donor, and in the Lick Observatory we submit to you a work which is the resultant of the most carefully studied and thoroughly discussed selections, from the best advice and information that the Trustees could obtain from the most eminent astronomers, and the most famous opticians and mechanicians in the world. To gather from many sources the best information on every point, and to shape the best ideas into a great observatory, on the summit of a remote mountain, has been no easy task.

Confident that the Lick Observatory will soon speak for itself in the world of science, and to the honor and fame of our University of California,

I am very truly yours,

R. S. FLOYD,
President Lick Trustees.

ADDRESS OF THE TRUSTEES OF THE JAMES LICK TRUST.

By EDWIN B. MASTICK, Trustee.

On the first day of June, 1888, the Trustees of the James Lick Trust, through a committee duly appointed by the Regents of the University, composed of Regents Hon. J. S. Hager, Mr. A. S. Halladie, and Hon. T. G. Phelps, conveyed by proper instruments the land whereupon the great telescope, Observatory, and all the machinery connected therewith now is, to the corporation known as the "Regents of the University of California," and also paid over to them the sum of $90,000 in United States gold coin, being a part of the fund which remained after the completion of the Observatory, and the possession of all was delivered through the committee to the Regents; and now, in a more formal way and on this public occasion, the Trustees come to the University, in the presence of the officers of the Regents and in the presence of this large assembly of the citizens of the State of California, and declare that they have fully executed and performed the third Trust imposed upon them by James Lick in his Deed of Trust, which, among other notable and excellent things, provided for the "purchase of land and constructing and putting up a telescope superior to and more powerful than any telescope ever yet made, with all the machinery appertaining thereto and appropriately connected therewith, or that is necessary and convenient to the most powerful telescope now in use, or suited to one more powerful than any yet constructed; also a suitable observatory connected therewith."

The execution of the trust required and demanded long and protracted study, investigations, visits to all the principal observatories in Europe and America; personal acquaintance, consultation, and correspondence with the most eminent

astronomers, opticians, and astronomical mechanicians in the world. At that time it was an undecided problem among astronomers as to which kind of a telescope was the best and most powerful—a refractor or a reflector.

Professor Simon Newcomb, of the Washington Observatory, in 1874, at the request of D. O. Mills, then a Trustee, visited Europe and investigated the subject of Observatories and instruments, and he made a full report of his observations.

Capt. R. S. Floyd, in the spring of 1876, consulted with Professor Newcomb on the subject, took letters of introduction from him, and in June was in London. And during that year he was enabled to visit nearly all of the Observatories in the old world, and consult and advise with the ablest astronomers and opticians there. Sir Howard Grubb showed to him the Observatory at Trinity College, Dublin. Mr. Grubb was at that time making at his works in Dublin the twenty-seven and one half-inch refractor for Vienna. He was introduced to Dr. Copeland, who then had charge of the Lord Ross reflector at Parsonstown, Ireland. At Mr. Grubb's suggestion, subsequently made, the floor in the great dome was made to rise and fall by water power.

He visited Dr. Huggins' Observatory at Upper Tulse Hill, London, where was both a refractor and reflector. Also visited Mr. William Lassel at Maidenhead, England. Mr. Lassel had made a forty-eight-inch reflector, and his reputation stood pre-eminent as to knowledge and experience concerning reflectors.

At Paris he saw the eminent M. Le Verrier, the director of the Paris Observatory, and through the courtesy of M. Le Verrier he was enabled to obtain the views of several of the members of the Academy of Sciences, as well as the advice of M. Le Verrier himself.

He visited the Observatory at Marseilles, and M. Stefan exhibited to him the new meridian circle by —— Eichens, and the first silver on glass reflector made by the distinguished M. Faucault, its inventor.

At Edinburgh, he saw many of the members of the British

Association, and at Glasgow, attended a meeting of that association, and was introduced to many of its members, consulted with them freely, and obtained a large amount of valuable information.

Among the decided advocates of a reflector, were Dr. Huggins, Dr. David Gill, and Dr. Copeland. Mr. Lassel thought that no great advantage could result from any reflector beyond forty-eight inches in diameter. Most of the distinguished astronomers consulted were undecided upon this point.

The result of his investigation, together with his knowledge of the peculiar circumstances at Mount Hamilton, convinced Captain Floyd that a great refractor would be the most successful telescope in California, as shown by his letter to Mr. F. D. Atherton, dated October 24, 1876, in which he sums up his conclusion as follows: "I think Mr. Lick's idea of a great refractor is the right one. It is, in my opinion, considering all the circumstances, theoretical and practical, the wisest and safest thing to do to make the principal instrument of the Lick Observatory, a refractor."

The sequel has shown that the opinion was well founded, and that the selection of a refractor has produced the most powerful and effective instrument.

The Trustees have been greatly aided by the advice and counsel of astronomers of this country and of Europe, who, for the interest of science, cheerfully responded to every request of the Trustees for counsel.

Among these must be mentioned, first, Prof. Simon Newcomb, of the National Observatory, at Washington. The files of correspondence are weighty with letters and reports from him furnishing advice on the subject of instrument and Observatory construction. The Trustees have also been ably and voluntarily assisted by Prof. Edward S. Holden, now the Director of the Great Lick Observatory; Prof. S. W. Burnham, who investigated the atmospheric condition of the mountain; the late Dr. Henry Draper, of New York; the late U. T. Leverrier, of Paris Observatory; Dr. Wm. Huggins, F.R.S., of London;

Dr. David Gill, Astronomer Royal, Cape of Good Hope; Dr. Johann Palisa, of Vienna; Prof. A. Krueger, Kiel, Prussia; Prof. Arthur Auwers, Berlin; Professor Langley, now Secretary of Smithsonian Institution; Professor Young, Princeton; Professor Harkness, Washington; Professor Hastings, New Haven; Professor Ewing, Dundee; Prof. David P. Todd, Amherst, Massachusetts; Prof. G. C. Comstock, now Director Washburn Observatory, Madison, Wisconsin; Prof. O. Stone, Mt. Lookout, Virginia; Sir Howard Grubb, Dublin, Ireland; Prof. William Lassel, F.R.S., Maidenhead, England; Prof. John Le Conte, University of California; Prof. C. W. Pritchett, Morrison Observatory, Missouri; Prof. James C. Watson, Madison, Wisconsin; Professor Davidson, of San Francisco; and many others.

The advancements made by Henry Brothers, of Paris, in Stella Photography, showed the Trustees the great and enormous advantages that would be promised by the addition to the Lick telescope of a photographic corrector, and they concluded to procure one if possible. Mr. Clark, of Alvan Clark & Sons, visited M. Mantois, of Paris, successor of the elder Feil, deceased, at the request of the Trustees, and succeeded in obtaining a block of crown glass that would work thirty-four inches clear aperture. This glass has been successfully figured and mounted. Mr. Clark pronounced it the best crown glass he ever saw, and it now constitutes the photographic corrector of the Lick telescope, and being so used makes the largest photographic instrument in the world.

In the year 1873, Mr. Lick began to consider this subject, and under his instruction, Mr. Fraser examined Mount St. Helena, and thereafter Mount Hamilton, and it was upon his report that Mount Hamilton was selected. From the fall of 1876 to the fall of 1887, Mr. Fraser was the able assistant of Captain Floyd and of the Trustees. He was thoughtful, intelligent, honest, and efficient. He made himself thoroughly acquainted with the mechanism of astronomical instruments, and under the direction of the Trustees, he visited and exam-

ined all Observatories in the United States, and consulted and advised with many men engaged in astronomical work, with respect to the construction of this Observatory, and so he was enabled to carry forward the work intelligently and without mistakes to its completion.

To the Board of Supervisors and to the people of Santa Clara County great credit is due.

After Mr. Lick had selected Mount Hamilton as the most available site for the Observatory, he suggested to the Board of Supervisors, through Hon. B. D. Murphy of San Jose, that the county should build a road to the top of the mountain; thereupon the Supervisors accepted the suggestion, provided Mr. Lick would advance the necessary money upon the warrants of the county, which he did, and the best mountain road in the State of California was constructed at a cost of $80,000. The money was afterward repaid by the people of the county through taxation.

For a further and more accurate description of the Observatory, great telescope, subsidiary instruments, and the work done, reference is made to Volume I of the Publications of the Lick Observatory.

The co-Trustees, in their own behalf, here express their high appreciation of the services of Captain R. S. Floyd. Since 1876 he has given to this work a large portion of his time, and for the past two years, to his great inconvenience and to the serious injury to his health, he has continuously resided on Mount Hamilton, and given all his time and best thoughts to the construction and completion of the Observatory.

The construction of so large a telescope involved many new problems and devices, and before anything was determined upon, he made himself thoroughly acquainted with that which was to be done, and the result which was to follow. He knew the point to be attained, and he sought and obtained the best means.

The Observatory, as it now is, was evolved from the knowledge derived by him from the most eminent astronomers,

opticians, and astronomical mechanicians in the world, all of whom have freely and earnestly given their opinions and advice based upon their investigations and experience.

Such was the desire and wish of Mr. Lick. He desired that the Observatory and this great telescope should embrace all that was good and most fit for astronomical work, and should be the result, not of the opinion or theory of one, but of the combined wisdom of all; and thereafter that it should be conducted and used for the discovery of the now hidden truths of the sidereal heavens, and the dissemination of such discoveries among the people.

Captain R. S. Floyd, by his love of science, sound judgment, devotion of his time, and with great industry, has gathered together all the knowledge and experience which existed in the world concerning the construction of Observatories, the excellencies and requirements of astronomical instruments. He has continually corresponded and consulted with the ablest and most experienced men. He has written more than five thousand letters, and has received upward of three thousand letters, gathered into ten large volumes, and the result of all, is this noble Observatory, with the greatest and most powerful telescope the world ever saw.

This Observatory, and this great instrument, we now commit to your fostering care.

The trust imposed upon us has been finished, and we believe that as this great instrument explores the sidereal expanse, it will develop new and wonderful things to man, thus exalting his knowledge, and making him more fit for the uses designed by his Creator.

The Trustees also here express their high appreciation for the able manner in which the work was done by Mr. Ch. Feil, and M. Mantois, in the making of the great glasses; the figuring of the same by Alvan Clark & Sons; the construction of the mounting of the telescope by Warner & Swazey, of Cleveland, Ohio; and in the inventive genius exhibited by them in the movable parts of the instrument, and in the construction

of the steel dome and elevating floor, by the Union Iron Works, of San Francisco, and to all the workmen and material men who have been engaged in the construction of the Observatory. Every one who has had anything to do in the production of the work has entered into it with spirit and zeal worthy of its great founder.

James Lick was born in Pennsylvania in August, 1796, and died in San Francisco October 1, 1876. By trade he was a piano maker. Industry and thrift gave him wealth enough to leave to his fellow-men this noble Observatory, a standing monument for the enlightenment of mankind, and with other donations made by him, his personality has become linked to a line of events which will give to him the crown of undying remembrance.

Within the foundation and under the pier which supports the great telescope, covered by the great dome, lies the mortal remains of James Lick. He gave no instructions concerning the disposition of his mortal remains, but Mr. Floyd, in a consultation with him, suggested that place as a proper place for his dead body. Mr. Lick made no reply, and on Sunday, the ninth day of January, 1887, in the presence and with the assistance of the representatives of the Regents of the University, of the representatives of the Pioneers of California, and of the representatives of the Academy of Science, his remains were identified and then placed where they now lie, and we his Trustees, now commit them to your reverent keeping.

R. S. FLOYD,
CHARLES W. PLUM,
E. B. MASTICK,
GEO. SCHONEWALD,
Trustees.

H. E. MATHEWS, Secretary.

RESPONSIVE ADDRESS IN BEHALF OF THE BOARD OF REGENTS.

The completion of the Lick Observatory, and its transfer to the University, marks an epoch, so important in the history of the State, in the history of the University, and in the history of science, that some kindling of the enthusiasm, perhaps, what on another occasion might seem some extravagance of language, will not, I am sure, be amiss.

The story of the munificent gift, and of the admirable way in which the intention of the giver has been carried out, has already been told you. I shall not repeat it. In accepting the splendid gift, I only ask your attention to a few words in praise of the noble science so munificently endowed.

Nature is a divine book—a book in which is revealed the thoughts and modes of operation of the divine intelligence. Science is the systematic interpretation of this book—a rational system of natural theology. Ideally, therefore, all natural truth is equally—because all is infinitely sacred. All departments of nature are equally important, all equally worthy of study, because all are infinitely so. The organization of an insect is as worthy a subject of human investigation as the organization of the solar system. Yet to *us*, whose finite minds cannot grasp the significance of the infinite whole, and, therefore, the relation of each part to that whole, to *us* some parts of nature, and some departments of science, seem nobler than others. Nature is an infinitely complex and yet perfectly concerted Divine Harmony. Every part is equally necessary for the grand total effect. But to *us*, unable to take in at once the whole cosmic harmony—to *us* listening, indeed, in ecstasy, but catching only broken snatches of this divine music, some strains seem sweeter and nobler than others. Dropping the metaphor: although all sciences are equally worthy, yet to *us*, some departments, by the mere magnitude of the objects, and

the vastness of the conception with which they deal, strike the imagination, and kindle the enthusiasm in a peculiar degree. Pre-eminent, it seems to me, in this respect, stand the two sciences, *Astronomy* and *Geology*. All will, I am sure, acknowledge the transcendent dignity of Astronomy, and help to-day to crown her Queen of the Sciences; but there is another science, Geology, which in the future must stand beside her as twin sister—distinguished from all others by superior dignity. I wish now by brief comparison and contrast of these two sciences to bring out in stronger relief the grandeur of both, but especially of Astronomy. For it is only thus, that as a geologist, and looking, as it were, through a geological telescope, I can best magnify the claims of Astronomy.

I. There are two, and only two, fundamental conditions of finite existence, viz., Space and Time. We cannot even conceive of existence, except under these two conditions. Now, the domain of Astronomy is space; of Geology is time. Other sciences, indeed, deal also with space—limited space, portions of space, but it is the prerogative of Astronomy alone to deal with infinite space. So other sciences also deal with time, limited time, portions of time, but it is the prerogative of Geology alone to deal with infinite time. As Astronomy is limited in time to about two thousand years, but unlimited in space, so Geology is limited in space to the surface of this earth, but unlimited in time. As Astronomy measures her spaces by earth-radii, so Geology her times by earth-cycles. As Astronomy takes the radius of the earth as a grand base-line, to measure the dimensions of the solar system, so Geology takes the present epoch and causes now in operation as a measuring rod wherewith to estimate the dimensions of the tertiary period. As the astronomer, growing bolder as he rises, takes next the diameter of the earth's orbit as a greater base-line wherewith to estimate the distance of the fixed stars, or even dares to speculate concerning the distance of the faintest nebulæ, hanging like scarcely visible wisps of cloud in the infinite depths of space beyond, even so the geologist takes

next the tertiary rocks as a greater measuring rod, to estimate approximately the almost inconceivable lapse of time represented by the secondary era, or even dares to cast his telescopic glance back into the dim nebulosity of earliest primordial to the first syllable of recorded time. Finally: as the astronomer, when telescopic vision fails, still speculates, though filled with awe, concerning the possible contents of the infinite abyss of space still beyond, even so the geologist, when fossils and stratified rocks are no longer visible—when looking back along the vista of time the milestones grow dimmer and dimmer, and finally disappear, still peers with wondering gaze into "the dark backward and abysm of time," knowing that all he sees or can ever hope to see—all he knows or can ever hope to know—is but a fragment of the unknown, unrecorded abyss beyond. Thus by both are we reminded that our own intellect, so daring, so arrogant, so apparently limitless, is itself but a spark of the infinite intelligence.

Thus, as Astronomy fills the universe of space with *objects*, Geology fills the universe of time with *events*. As Astronomy carries us *upward* by the laws of Geometry, Geology carries us *backward*, by the laws of cause and effect. As the Astronomer in his gigantic march through space steps from star to star by a chain of triangles, so the Geologist in his march through time steps from epoch to epoch of the earth's history by a chain of organical and mechanical laws. As Astronomy binds the whole space-universe into an orderly cosmos by the universal law of Gravitation, so Geology binds the whole universe of time into a time-cosmos, by the no less universal law of evolution.

II. The mission of science is to demonstrate the universal reign of law; to demonstrate the existence of perfect harmony in the midst of apparent confusion; of perfect unity in the midst of infinite diversity; unity of *force* in the midst of infinite diversity of phenomena—physical science; unity of plan in the midst of infinite diversity of form, or unity of thought in the midst of infinite diversity of expression—Natural Sci-

ence, in a word, the unity of God in the infinite multiplicity of nature. This is the mission of *all* science. But it is the privilege of Astronomy alone to demonstrate this unity throughout all space, as it is of Geology throughout all time. As Astronomy shows that the same law which controls the falling of a stone guides also the planets in their fiery courses, even so Geology shows that the same law which now controls the development of an organism from egg to maturity, has also guided the development of the earth and the organic kingdom from primal chaos to its present condition; that the same intelligence which now controls the one has, through infinite ages, presided over the other; that there has been no new law nor change of purpose, but the ceaseless activity of Deity has operated only in the eternal unfolding of the original conception. Thus, as Astronomy more than all other sciences demonstrates the presence of the same Divine energy throughout all space, so Geology, more than all other sciences, demonstrates the presence of the same Divine energy throughout all time. If one demonstrates that glorious attribute of Deity, His omnipresence in infinite space, the other demonstrates that other correlative and equally glorious attribute—His eternal unchangeableness in infinite time.

Or again: we have all heard of "the Music of the Spheres"—a beautiful and significant name used by the old thinkers for the Divine Order of the Cosmos—a music not heard by human ear, but only by the attentive human spirit. Harmonic relations apprehended by reason, we call natural *Law*, and its embodiment, Science; the same harmonic relation apprehended by the imagination and the aesthetic sense, we call *Beauty*, and its embodiment *Art*, Music. Now, in music, there are two kinds of harmony, ~~one~~ viz. simultaneous and consecutive, or chordal harmony and melody. These two must be combined to produce the grandest choral effects. So in cosmic order, too, there are two kinds of harmonic relations—the *co-existent in space* and the *consecutive in time*. The law of gravitation, the great law of astronomy, expresses the ~~unmusi~~ universal

harmonic inter-relation of objects co-existent in space; the law of evolution, the great law of geology, expresses the universal harmonic relation of forms or events successive in time. Of the divine spheral music, the one is the chordal harmony, the other the consecutive harmony or melody. Together they form the primal divine chorus which "the morning stars sang together, and all the sons of God shouted for joy."

III. In the history of science there are two eras which especially arrest the attention of the thoughtful mind, or rather, I should say, two moments, the greatest in the intellectual history of our race. These are those in which were first born in the mind of man and fully realized the fundamental ideas underlying astronomy and geology the infinity of space and infinity of time. You have all doubtless thought of the sublimity of the moment when the idea of infinite space was first clearly realized by the mind of man. You have all shared the ecstasy of Galileo, when "gazing through Tuscan glass on the top of Fisole," the phases of Venus and the satellites of Jupiter revealed clearly the existence of other worlds besides and like our own. Doubtless the idea had already been conceived in the mind of Copernicus, but it was fully born into the world only from the mind of Galileo. Before that pregnant moment *our* earth was *alone* in the universe. Sun, moon, and stars were but little satellites, moving at inconsiderable distances about us and created for our behoof. Before that pregnant moment, astronomy was but the geometry of the heavens—the geometry of the curious lines traced by these wandering fires on the concave blackboard of heaven. In an instant all was changed, and modern astronomy was born. In an instant, the idea of infinite space filled with worlds, was born and became thenceforward, forever, the heritage of man. In an instant the intellectual horizon of the human race was infinitely extended, but our own earth, the home of our race, before so great, dwindled into a mere speck in the infinite abyss of space. You have doubtless all thought of this as the grandest moment in the onward march of intellectual progress. But there is another moment equally grand though less thought of, viz.:

that in which was born the corresponding idea of infinite time, the fundamental idea of geology.

The history of its introduction is interesting. It had long been known that marine shells and other evidences of oceanic action were found far in the interior of continents and high up the slopes of mountains. There had been much speculation concerning the origin of these relics. Most regarded them as evidences of the Noachian deluge. Some thought, more truly, that they were evidences of slower and more permanent changes in the relation of sea and land. But none imagined that they belonged to any other epoch than our own. Some may have imagined that by these discoveries they were extending a little the limits of our own time; but none imagined that these were relics of other times than ours. Some may have imagined that they were discovering new coast islands along the shores of Time, but none that these were evidences of new *worlds* in the infinite Ocean of Time.

Such was the condition of things when, about the end of the last century and in the evening of his long and great life, a large number of these relics—both marine shells and bones of mammals—were brought to the notice of the naturalist Buffon. Aided by his extensive knowledge of comparative anatomy, he at once saw that they all, especially the mammals, belonged to species wholly different from any now inhabiting the earth. In that moment—in the mind of the aged Buffon, ~~and truly~~ suddenly like Minerva, from the head of Jove—was born the fundamental idea of Geology. Until that moment, our epoch—the life of our race—was all of time. In an instant was born the idea of infinite Time containing other epochs—other time-~~s~~ worlds than ours. In an instant the intellectual horizon of man was again infinitely extended, but our own time—the life of our race, which before was all of time—again dwindled into an insignificant day in the grand march of the earth's history.

IV. But the importance of any department must be judged also, and perhaps mainly by its capacity of being used as a means of mental culture—as a means of cultivating the powers of the mind, and practicing in the methods of discovering

truth. And here again we shall find the same complementary relation.

The human mind sometimes discovers truth by intuition, *i. e.:* by processes of reasoning so rapid and subtile, that they elude our power of analysis. This *intuitive* method is the province of Genius. But the distinctive characteristic of science is the use of *regular* methods in the discovery of Truth. Scientific methods in the sphere of intellect may be compared to instruments and machines in the lower sphere of matter. They are intellectual contrivances, indirect methods of reaching what would otherwise be unattainable. As in the lower realm of matter, the civilized man is not superior to the savage in bare-handed, physical strength, and his greater power over physical nature is wholly due to the use of mechanical contrivances; so in the higher realm of spirit, the cultured man is but little superior to the uncultured, in simple, unaided mental power; his great superiority in the acquisition of truth is wholly due to the use of intellectual contrivances, or scientific methods. Among these intellectual contrivances, by means of which all the wonderful results of modern intellect have been achieved, are the *method of notation*, characteristic of mathematics and mathematical sciences, including astronomy, the *method of experiment*, so characteristic of physics and chemistry, and the *method of comparison*, characteristic of all the biological sciences, including geology and sociology. I might stop here to compare and contrast the two extreme methods—the mathematical and comparative—the one characteristic of astronomy and the other of geology. I might show their different effects on the mind, and therefore their complementary function in education. I might especially show that the mathematical and experimental methods are the chief means in acquiring knowledge of a power over nature; the method of comparison the chief means of acquiring knowledge of and power over men. But this would carry me too far. I can best serve my purpose, which is to show the complementary relations of our two favorite sciences by comparing them as to the use of the two great converse processes underlying all scientific methods.